State Board of Education Approved
October 2001

PRINCIPLES OF ENGINEERING

COURSE DESCRIPTION

Principles of Engineering **is a course in which students explore the nature of engineering and the skills fundamental to all engineering fields, as well as the role of quality-assurance and quality control procedures in manufacturing. Emphasis is placed on actual projects and presentations and the use of modern tools (e.g., CAD). The course can be enhanced by cooperation with local manufacturing facilities, which can provide real measurement data and opportunities for on-site visits to witness engineering tasks and projects, and quality-control data collection.**

Prerequisite(s): **Engineering Design/CAD; Algebra I or Math for Technology II; Geometry**

Recommended Credits: **1**

Recommended Grade Level(s): **10th, or 11th, or 12th**

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PRINCIPLES OF ENGINEERING STANDARDS

1.0 Students will explore careers available in the engineering and manufacturing areas.

2.0 Students will produce engineering designs for a structure.

3.0 Students will produce workable engineering designs according to specifications and within given constraints.

4.0 Students will analyze the impact of quality on cost and productivity, product design, and manufacturing processes.

5.0 Students will implement quality assurance (QA) inspection and testing procedures in a manufacturing environment.

6.0 Students will use statistical tools to assure quality in manufacturing processes.

7.0 Students will demonstrate leadership, citizenship, and teamwork skills required for success in the school, community, and workplace.

PRINCIPLES OF ENGINEERING

STANDARD 1.0

Students will explore careers available in the engineering and manufacturing areas.

LEARNING EXPECTATIONS

The student will:
1.1 Investigate possible career paths for engineers and engineering technicians.
1.2 Examine the potential roles and responsibilities of an engineer or engineering technician.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:
1.1.A Maps out various career path options for the field of engineering.
1.1.B Compares the academic and professional qualifications of engineers and engineering technicians.
1.2.A Assesses the role of engineering in a technological society.
1.2.B Compares and contrasts the functional roles of design, production, and industrial engineers.
1.2.C Determines the roles and qualifications of specific engineers and technicians in various companies and industries based on their experiences during field trips.
1.2.D Analyzes the roles and skills contributed by members of engineering teams.

SAMPLE PERFORMANCE TASKS

- Students present findings on engineering career opportunities after doing a Web search for engineering jobs.
- Students compile news stories involving the impact of engineering on society.
- Students report on observations and data gathered during field trips to area sites with active engineering facilities.

INTEGRATION/LINKAGES

Foundation for Industrial Modernization (FIM). *What Manufacturing Workers Need to Know and Be Able to Do: National Voluntary Skill Standards for Advanced High Performance Manufacturing*. Washington, DC: National Coalition for Advanced Manufacturing, 1995. International Technology Education Association. *Standards for Technological Literacy: Content for the Study of Technology.* International Technology Education Association. Reston, VA, 2000. Manufacturing Skill Standards Council. *A Blueprint for Workforce Excellence (draft skill standards for manufacturing.)* Manufacturing Skill Standards Council, 2001. Project Lead the Way curriculum. Career exploration content. *Total Quality Management*, SkillsUSA-VICA.

PRINCIPLES OF ENGINEERING

STANDARD 2.0

Students will be able to produce engineering designs for a structure.

LEARNING EXPECTATIONS

The student will:
2.1 Create and interpret engineering designs including bills of materials.
2.2 Evaluate drawings and material lists.
2.3 Create models from drawings.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:
2.1.A Determines a bill of materials based on drawings and specifications produced by others.
2.1.B Produces a design drawing with sufficient detail and accuracy for others to be able to construct the structure.
2.2.A Critically examines drawing specifications for self-consistency.
2.2.B Critically examines material lists for self-consistency.
2.3.A Creates a clay or paper model of a three-dimensional object from drawings created by others.
2.3.B Creates a clay or paper model of a three-dimensional object from their own drawings.

SAMPLE PERFORMANCE TASKS

- Students read drawings and specifications produced by others.
- Student groups produce drawings and design specifications for simple structures that can be constructed with cardboard or balsa wood.
- Student groups execute the design produced by another group.
- Student groups critique the drawings of another group before accepting the construction project.

INTEGRATION/LINKAGES

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PRINCIPLES OF ENGINEERING

STANDARD 3.0

Students will produce workable engineering designs according to specifications and within given constraints.

LEARNING EXPECTATIONS

The student will:
3.1 Design a mechanism project
3.2 Execute a mechanism project.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:
3.1.A Produces and presents mechanism product concepts, including constraints on time, resources, and so on, for approval.
3.1.B Completes, documents, and presents a product design that satisfy the concept constraints for approval.
3.1.C Creates prototype production plans that satisfy the concept constraints and present it for approval.
3.2.A Executes their design and production plans to produce working prototypes.
3.2.B Evaluates their prototypes and determine whether they meet their concepts and imposed constraints.

SAMPLE PERFORMANCE TASKS

- Students complete a mechanism design project from concept to prototype, with appropriate approval stages throughout the process.
- Students serve as members of engineering teams.

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STANDARD 4.0

Students will analyze the impact of quality on cost and productivity, product design, and manufacturing processes.

LEARNING EXPECTATIONS

The student will:

4.1 Analyze the relationship between process management and quality assurance.
4.2 Evaluate the effects of quality procedures on all aspects of a manufacturing system.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

4.1.A Incorporates principles of process management in a manufacturing process.
4.1.B Assesses potential advantages of process management.
4.1.C Validates the need for feedback loops within a system.
4.1.D Devises modifications to a manufacturing process based on quality concepts.
4.2.A Analyzes and quantifies (where possible) the impact of a given quality issue on cost and productivity.
4.2.B Analyzes and quantifies (where possible) the impact of a given quality issue on product design.
4.2.C Analyzes and quantifies (where possible) the impact of a given quality issue on manufacturing processes.

SAMPLE PERFORMANCE TASKS

- Students analyze the role of quality in a manufacturing scenario or case study.
- Students research and report on quality control incidents showing the effects of inadequate quality-control procedures (e.g., Firestone tires, Challenger space shuttle disaster).

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STANDARD 5.0

Students will implement quality assurance (QA) inspection and testing procedures in a manufacturing environment.

LEARNING EXPECTATIONS

The student will:
5.1 Inspect raw materials and intermediate products.
5.2 Inspect and test final products.
5.3 Design sampling plans.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:
5.1.A Justifies the need for inspection of raw materials and intermediate products.
5.1.B Performs accurate inspections of raw materials and intermediate products.
5.2.A Justifies the need for final product inspection and testing.
5.2.B Performs accurate inspections and tests of final products.
5.2.C Demonstrates the difference between inspection and testing of a given product.
5.3.A Designs a rudimentary sampling plan for a given manufacturing process.
5.3.B Validates a rudimentary sampling plan for a given manufacturing process.

SAMPLE PERFORMANCE TASKS

- Students compare and contrast the roles of inspection and testing.
- Students complete case studies of various QA techniques, illustrating 100% inspection versus sampling.

INTEGRATION/LINKAGES

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STANDARD 6.0

Students will use statistical tools to assure quality in manufacturing processes.

LEARNING EXPECTATIONS

The student will:

6.1 Perform statistical procedures commonly used to monitor quality in manufacturing.
6.2 Use statistical process control concepts to evaluate and modify manufacturing processes.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

6.1.A Demonstrates basic statistical procedures used to collect, analyze, and report data.
6.1.B Communicates statistical concepts using common QA reporting methods, including control charts, histograms, pie charts, and statistical measures (average, range).
6.1.C Performs basic mathematical calculations, calibrations, and measurements.
6.2.A Designs a sampling plan based on information including previous history of failure and target quality goals.
6.2.B Performs a Pareto Chart analysis.
6.2.C Traces the source of any large disparity using the following tools and concepts:
- control charts
- histograms and specifications
- variability and predictability
- shape of a distribution, measures of center, measures of spread
- interpreting a curve and plotting the X-bar and R control chart
- special cause variation

6.2.D Recommends modifications to a manufacturing process based on statistical process control data.

SAMPLE PERFORMANCE TASKS

- Students apply basic statistics used in QA (mean, range) to data collected on common school processes (e.g., flow of students through a doorway, expenditures in cafeteria).
- Students use MIL-STD105D to create sampling plans for given processes, based on information gathered at a local manufacturing plant.
- Students measure a poorly controlled process (e.g., breaking pasta noodles) to collect data, apply an inspection process, and summarize the data, comparing it to a specified tolerance.
- Students analyze data provided by a local manufacturing facility, using an X-bar/R-chart, comparing it to control parameters provided by the facility.

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STANDARD 7.0

Students will demonstrate leadership, citizenship, and teamwork skills required for success in the school, community, and workplace.

LEARNING EXPECTATIONS

The student will:
7.1 Demonstrates dignity in work.
7.2 Participate in SkillsUSA-VICA as an integral part of classroom instruction.
7.3 Evaluate school, community, and workplace situations by applying problem-solving and decision-making skills.
7.4 Demonstrate the ability to work professionally with others.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:
7.1 Demonstrates leadership skills through exhibiting characteristics of integrity and pride in work.
7.2.A Demonstrates employability skills.
7.3 Analyzes situations in the workplace and uses problem-solving techniques to create a desirable environment.
7.4.A Participates in job shadowing in an area of the engineering industry.
7.4.B Manages an officer or national voting delegate campaign with Tennessee SkillsUSA-VICA.

SAMPLE PERFORMANCE TASKS

- Prepare a resume.
- Participate in various SkillsUSA-VICA programs and/or competitive events.
- Attend a professional organization meeting such as, Chamber of Commerce meeting.
- Participate in the American Spirit Award competition with SkillsUSA-VICA.
- Develop a plan of action for an officer candidate or national voting delegate.
- Participate in job shadowing or internship within the engineering industry.

INTEGRATION LINKAGES

SkillsUSA-VICA, Professional Development Program, SkillsUSA-VICA, Communications and Writing Skills, Teambuilding Skills, Research, Language Arts, Sociology, Psychology, Math, Math for Technology, Applied Communications, Social Studies, Problem Solving, Interpersonal Skills, Employability Skills, Critical-Thinking Skills, SCANS (Secretary's Commission on

Achieving Necessary Skills), Chamber of Commerce, Colleges, Universities, Technology Centers, and Employment Agencies

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SAMPLING OF AVAILABLE RESOURCES

Introduction to Engineering Technology and Engineering. Prentice-Hall, 2001.
Introduction to Statistical Quality Control. John Wiley & Sons, 1996.
Introduction to Industrial and Systems Engineering. Prentice-Hall, 1992.
Achieving the Competitive Edge: A Practical Guide to World-Class Competition. John Wiley & Sons, Inc., 1996.
Achieving Stretched Goals: Best Practices in Manufacturing for the New Millennium. Prentice-Hall, 1997.